Disturbance to Brown Pelicans at Communal Roosts in Southern and Central California

Prepared for the
American Trader Trustee Council
California Department of Fish and Game
United States Fish and Wildlife Service
National Oceanic and Atmospheric Administration

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October 15, 2002

EXECUTIVE SUMMARY

Disturbance to Brown Pelicans at communal roosts in southern and central California was assessed using data from 235 flushing events observed over the period 1986-2000. This study was conducted to provide quantitative information on frequency, severity and sources of disturbance, to aid the American Trader Trustee Council (ATTC) in selecting and prioritizing restoration projects intended to enhance roost quality for the California Brown Pelican. Disturbance frequency in southern California averaged 0.53 flushing events per hour. Frequency and severity of disturbances to roosting pelicans in southern California were greatest in natural habitats, such as river mouths and other estuaries, and lowest at harbors and man-made structures along the outer coast. Eighty-five percent of all pelicans observed to flush due to disturbance were roosting in natural landscapes. Disturbance occurred about once an hour at estuarine roosts versus once every four hours on artificial substrates. More than 90% of all disturbance incidents were directly due to humans, mostly recreationists, rather than natural factors. Pelicans demonstrated habituation to the most common types of boat traffic in harbors. Human disturbance at southern California natural areas may be incurring relatively high energetic costs to immature pelicans and precluding regular use of otherwise desirable habitats by adults. Efforts to reduce disturbance will target different user groups, primarily recreationists, and vary according to roost habitat type. Artificial structures along the southern California coast are a critical component of nonbreeding habitat for Brown Pelicans, however the results of this study suggest that restoration actions geared towards reducing human disturbance at existing roosts should prioritize natural areas. Public education, establishment of 25-30 meter buffer zones between traditional pelican sites and people, and habitat manipulation to enhance or create island roost habitat are recommended.

Disturbance indices for two key central California roost sites included in this study were higher than for any southern California sites. Human disturbance frequency increased greatly in 1999-2000 compared to levels documented in the 1980's. Kayaks and ecotourism, along with habitat and water level management changes at the Moss Landing WA were responsible for much of the disturbance documented. Kayaks and other boats caused 77% of all observed disturbance events at these roost sites in 1999-2000. Immediate management intervention is recommended.

ACKNOWLEDGMENTS

This analysis was supported by the American Trader Trustee Council (ATTC) and the National Fish & Wildlife Foundation. Special thanks to Carol Gorbics (USFWS), Paul Kelly (CDFG) and Jennifer Boyce (NOAA) for facilitating the project. The ATTC supported field work in 1999-2000. Historical data were provided thanks to research funded, supported, or in cooperation with, Dan Anderson (UC, Davis), Dave Harlow (USFWS), John Gustafson and Paul Kelly (CDFG, Sacramento), Harry Carter (Humboldt State University, Arcata, CA), Tom Keeney (Naval Base Ventura County, Point Mugu California), and Janet Didion (California Dept. of Recreation, Sacramento). Laird Henkel (H.T. Harvey and Associates), Bradford Keitt and Holly Gellerman (Island Conservation and Ecology Group) assisted with field surveys in 2000. This report was improved by reviews from Carol Gorbics and Paul Kelly.

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INTRODUCTION

Human disturbance causes direct and indirect effects on birds in nonbreeding habitats that are often difficult to measure. The most obvious direct effect is flight behavior, which in itself causes variable levels of energy expenditure, depending on the metabolic cost of flight by species, duration and type of flight (Pennycuik 1972). Chronic disturbance to nonbreeding birds can affect body condition, metabolic rate, habitat use, and subsequent reproductive success due to reduced lipid reserves (Stahlmaster 1983, Josselyn et al. 1989, Culik 1990, Gaston 1991). Long-term effects on bird distribution and habitat use have been inferred (Batten 1977, Burger 1981, Jaques and Anderson 1986, Cornelius et al. 2001).

Based on the anatomy, roost site selection and behavior of the California Brown Pelican (*Pelecanus occidentalis californicus*), it is evident that conserving energy is an important life history trait for these large migratory birds. Brown Pelicans spend much of their daily energy budget resting and maintaining plumage at traditional communal roosts (USFWS 1983, Croll et al. 1986). The less disturbance that pelicans experience at these roosts, the less energy they will expend responding to such events and the more energy they will be able to conserve by using favored locations of the coast and selected microhabitats within roosts. The quality of a roost site can be based then, in part, on measurements of disturbance frequency and severity.

Habitat availability, habitat selection, and disturbance to roosting Brown Pelicans are all interrelated. Brown Pelicans prefer to roost communally on dry substrate surrounded by water on all sides to avoid predators, particularly at night. During the day, locations that have less of a water buffer are often selected, since these areas may be in nearest proximity to food or have other attractive features (USFWS 1983, Strong and Jaques 2002). Roost sites that are not true islands are most vulnerable to disturbance. Nearshore island habitat is limited in southern California and human disturbance at roosts has been a management concern (USFWS, 1983, Jaques and Anderson 1988, Jaques et al. 1996, ATTC 2001, Capitolo et al. 2002).

This study was conducted to provide additional quantitative information on disturbance to Brown Pelicans in southern California, including analysis of frequency, severity and cause of disturbances. The results are intended to aid the American Trader Trustee Council (ATTC) in making plans for restoration projects intended to reduce disturbance and enhance roost quality.

METHODS

Observations and censuses of Brown Pelicans at communal roosts were made as part of ATTC restoration activities during 1999-2000 and as part of various projects for other purposes during 1986-1993. Disturbance data from 1986-1987 were collected as part of a master's thesis project (Jaques and Anderson 1987, Jaques 1994). Focused studies of disturbance and roost habitat use were made at and around Mugu Lagoon from 1991-1993 (Jaques et al. 1996) and at Moss Landing in 1987 (Jaques and Anderson 1988). Those data have been incorporated into this analysis where noted. Other data included in this report were collected incidental to a study of survival of rehabilitated oiled birds (Anderson et al. 1996) and as part of an inventory of marine bird and mammal use of California State Parks (Jaques and Strong 1996). Methods and observers were fairly consistent throughout this period, allowing comparison of disturbance frequency and source, by habitat, for all of the data set. Information on Brown Pelican response to disturbance was available for a subset of the historical data and all of the data collected in 2000. Data were grouped as historical (all data collected from 1986-1993) and recent (1999-2000), for analyses of changes over time.

The time and duration of observation, weather conditions and sea state, were recorded at each roost site. Pelicans were censussed by location and habitat type, with a breakdown of birds by age category. Pelican roost habitat types were categorized as follows:

OSR: Offshore rock or island, open coast.
CRS: Cliff or Rocky shore, on mainland shore of open coast.
BCH: Mainland shore open coast beach, sand or with rocky structure.
EST: Estuary. Large estuaries always open to the sea
RMO, CMO: River or Creek mouths, that often form smaller estuaries.
LAG: Estuaries that are frequently closed off from the ocean by a beach berm.
HRB: Harbor. All roost structures associated with harbors.
BRW: Detached breakwater. A subhabitat in harbors.
JTY: Jetty, attached to mainland. Most often a subhabitat within a harbor, but used as primary habitat type when not in association with a harbor.
MMS: Other man-made structures. Most often a subhabitat in harbor, but a primary habitat if on the outer coast.

For disturbance analysis, roost subhabitats within harbors were grouped together and referred to under the "Harbor" except where noted otherwise. River mouths, lagoons, and other estuaries were also grouped together under the general category "Estuary" in many of the analysis. Disturbance observations were not made at offshore rocks or beaches in southern California.

Disturbance to pelicans was defined as an event causing birds to flush rapidly from a roost. The following parameters were recorded when possible: the cause of disturbance, estimated distance from the disturbance source when birds flushed, number of birds flushed, fate of flushed birds (depart roost, relocate to different area, or reland), and any associated information (response of other species, percent of total roost affected, etc.). Disturbance frequency was measured as the number of disturbances per hour of observation. A measure of disturbance severity was measured with a modification of the Disturbance Index, "D," developed by Jaques et al. (1996) as:

$$D = \text{SQR ROOT}\left(\frac{N*(n\ \text{depart}*3)+(n\ \text{relocate}*2)+n\ \text{reland}}{\text{Hours of observation}}\right)$$

where N= the number of disturbances, and n depart, relocate or reland= the number of pelicans showing that response. Multiplication factors are included to weight more severe disturbance effects (departure and relocation).

Sources of disturbance in southern California were grouped into 12 categories. Ground-based disturbances by people were grouped in the category "walker" unless the persons were clearly engaged in other more specific categories, such as working ("worker"), surfing (surfer), or fishing from shore ("fisher"). Disturbances from watercraft were divided into kayaks, jet skis, and all other boats (fishing boats are grouped with other boats). Aircraft were divided into helicopters and all other aircraft. Disturbances by dogs, including people walking dogs, were included in the category "dog." Gun-based hunting and target shooting were grouped together as "shoot." Natural disturbance categories included waves, other wildlife species, and unknowns (no human disturbance recognized, no obvious cause).

RESULTS

Southern California

Disturbance Frequency

We documented 100 incidents of disturbance to Brown Pelicans in 189 hours of observations at roosts along the southern California mainland. Forty-six of these disturbance events were documented in 1999-2000, and 54 were part of the historic data set (Table 1). An additional 133 disturbance events were recorded during focused observations at Mugu Lagoon during 1991-93 (Jaques et al. 1996); these data were not included in the pooled information for southern California in this report, except where noted.

Disturbance frequency in southern California was 0.53 flushing events per hour over the entire sample period. The overall disturbance rate was slightly higher in southern California in 1999-2000 than in 1986-93 (Table 1). Disturbance rates were higher at seven roosts, lower at two roosts, and unchanged at two roosts in the recent period. Observation hours were relatively low at many southern California sites, however.

Disturbed Habitats

Frequency and severity of disturbances to roosting Brown Pelicans in southern California were greatest in natural habitats, such as river mouths and other estuaries, and lowest at harbors and man-made structures along the outer coast (Fig. 1). Pelicans at natural roosts were disturbed by people about once every hour, while pelicans at artificial roost sites were disturbed about once every four hours (N= 189 hours). Within harbors, pelicans at detached breakwaters were disturbed less frequently than those at jetties (0.28 compared to 0.36 disturbances/hour). The total number of pelicans observed flushed from all sources was 4,779 birds. Of these, 85% were roosting on natural substrates, and 16% were on artificial structures. There was a tendency for a higher proportion of the birds present to flush from a disturbance in a natural setting, compared to a harbor. All natural roost sites where disturbance was documented had a higher disturbance index than the artificially created roost sites (Table 1).

Table 1. Disturbance frequency and hours of observation at selected Brown Pelican roosts in southern California, 1986-1993 and 1999-2000. Roost sites are listed roughly in order of most to least disturbed. Human and natural disturbances are expressed as the number of disturbance per hour of observation (N). "D" is the Disturbance Index and pertains to data collected in 1999-2000 only. The disturbance index is described in Methods.

Roost No.	Roost Site	Hab.	1986-1993			1999-2000			
			Human	Natural	N	Human	Natural	N	D
LA 16.0	Malibu Lagoon	LAG	0.88	0.15	(6.8)	2.58	0.32	(6.2)	29.7
SD 1.0	Tijuana Slough	EST	1.43	0.32	(6.3)	ND	ND	ND	
VN 7.0	Santa Clara River	RMO	1.13	0	(11.5)	1.35	0.19	(5.2)	8.1
SD 4.0	Point Loma Cliffs	CRS	2.29	0	1.8	ND	ND	(.1)	-
SD 10.0	La Jolla Cliffs	CRS	ND	ND	0	1.0	0	2.0	5.8
LA 11.0	King Harbor	HRB	0	0	(3.0)	0.75	0	(8.0)	4.9
OR 3.0	Dana Point Harbor	HRB	0.28	0	(14.2)	0.58	0	(6.9)	1.6
VN 5.0	Channel Islands Harbor	HRB	0.4	0	2.5	0.51	0	(3.9)	0.5
SD 3.5	Zuniga Point	JTY	1.7	0	1.8	0	0	(3.2)	0
VN 4.0	Mugu Lagoon	EST	0.31	0.10	(322)	ND	ND	0	-
VN 8.0	Ventura Harbor	HRB	0	0	(2.7)	0.35	0	(8.7)	1.3
SD 12.0	Agua Hedionda Lagoon	LAG	0	0	3.2	0.28	0	(7.1)	4.2
LA 12.0	Marina del Rey Harbor	HRB	0.29	0	(17.5)	0.26	0	(3.8)	0.6
SD 11.0	Batiquitos Lagoon	LAG	0	0	1.3	0	0	(1.4)	0
OR 10.1	Bolsa Chica Lag.	LAG	0	0	1.2	0	0	(0.1)	-
SD 13.0	Oceanside Harbor	HRB	ND	ND	0	0	0	(1.2)	0
SB 4.0	Santa Barbara Harbor	HRB	0	0	12.7	0	0	(2.3)	0
SB 3.0	Santa Barbara Outer Harbor	HRB	0	0	2.6	historic roost site			
VN 10.0	Mobil Oil Pier	MMS	0	0	8.9	historic roost site			
	***SOCAL TOTAL**		**0.43**	**0.03**	**(120)**	**0.62**	**0.04**	**(69)**	

* does not include Mugu Lagoon

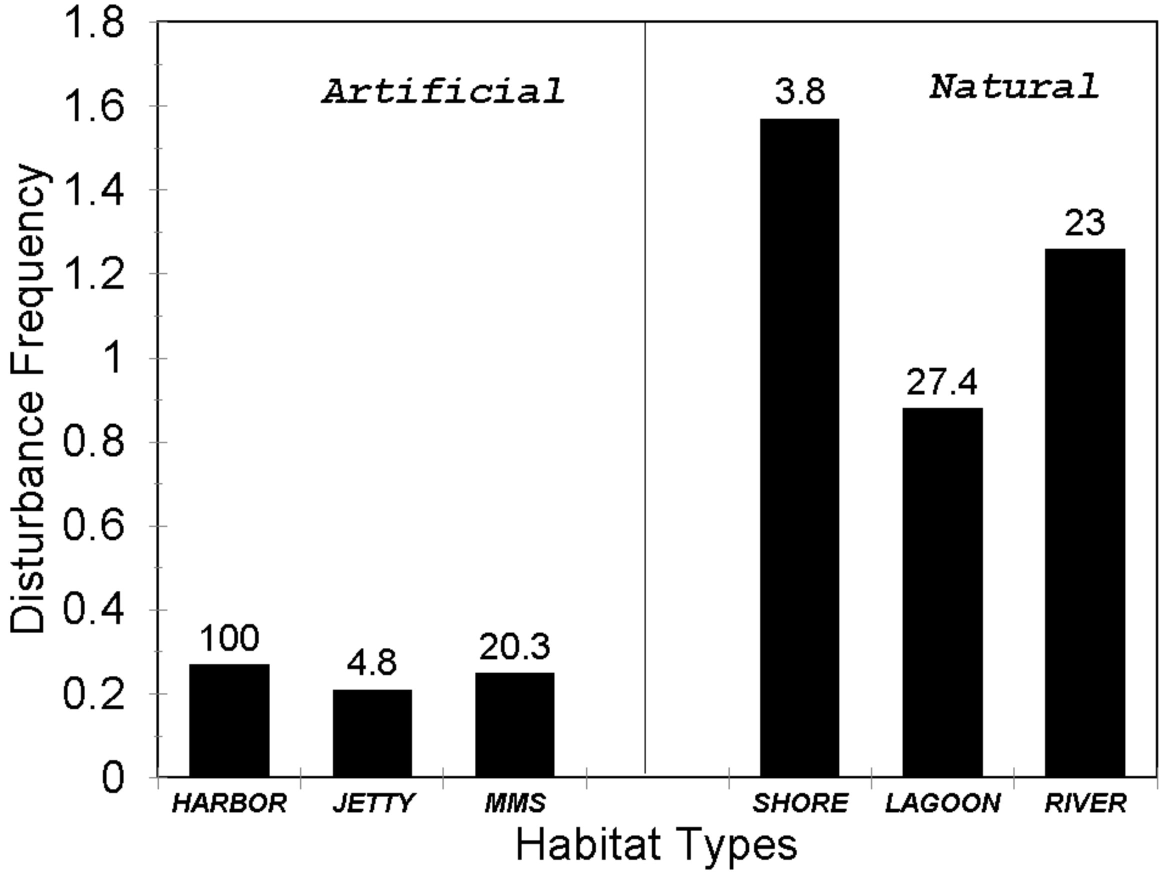

Figure 1. Frequency of human disturbance to Brown Pelicans at roosts in six general habitat types in Southern California. 'Disturbance frequency' is the number of disturbance events documented per hour of observation in each habitat type. The number of hours spent observing pelicans in each habitat is shown as the sample size on top of each bar. Habitat types are defined as follows: Harbor = all roosting substrates associated with harbors, including jetties, breakwaters and other man-made structures; Jetty= jetties on the outer coast, not closely associated with harbors; MMS= man-made structures not associated with harbors; Shore= mainland cliff or rocky shoreline; Lagoon= lagoon; River= river mouth.

Disturbance Types and Pelican Response

The greatest single source of disturbance was a person(s) on foot, approaching pelicans at a roost. This accounted for 32% of all disturbances seen from 1986-2000. In most cases the people were simply walking, but a few incidents involved more specific types of activities e.g., jogging, photographing. The second largest source of disturbance was from water-based recreational sports, including boating, surfing and fishing. Disturbances from watercraft and surfers were proportionally greater in 1999-2000 than in 1986-93 (Fig. 2). Collectively, these sports accounted for 13% of all disturbances in the early period compared to 37% in the latter period. In contrast, documented disturbances involving dogs decreased, from 17% of all disturbances in 1986-93, to 2% in 1999-2000. Natural disturbances were rare in southern California and accounted for less than 10% of all disturbances (N=100 disturbances).

Characteristic types of disturbance differed by habitat. In harbors, 50% of all disturbance events were caused by watercraft of some type, and 20% of disturbances were caused by fishermen on foot (Fig. 3). In estuarine habitats, 62% of all human disturbances were caused by people approaching pelicans on foot (including surfers); an additional 20% of events observed were caused by people with dogs.

The disturbance category causing the greatest total numbers of pelicans to flush was "walker" (Table 2). Boats, not including kayaks and jet skis, caused the fewest pelican to flush per incident on average. Disturbances by fishermen on foot caused the lowest total numbers of pelicans to flush, but these disturbances resulted in complete displacement of a relatively high proportion of birds from the roost site.

The most common pelican response to disturbance, after flushing, was to relocate within the same roost (Table 2). Of the disturbance events in which pelican fate could be tracked, 60% of the total relocated to a different area within the same roost, 26% returned to the same site within the roost, and 14% departed the roost entirely.

Flushing Distances

The distance at which pelicans flushed from a disturbance source varied by type of disturbance, roost habitat, and other variables. Pelicans flushed at the greatest distance from helicopters and allowed closest approach by kayaks (Fig. 4). Mean distances for each disturbance category indicated that pelicans allow closer approach by all types of boats than by persons approaching on foot. Pelicans flushed from walkers at a range of 20-50 meters and from boats at a range of 4-30 meters. Mean flushing distance in estuarine habitats was greater than mean flushing distance in harbors (26.3 versus 13.8 meters, respectively; N= 37 disturbance events).

Disturbed Locations

The most heavily disturbed traditional roost sites in Southern California were Malibu Lagoon, the Santa Clara River mouth, and Tijuana Slough. Each of these sites had disturbance frequencies exceeding one flushing event per hour. The harbors with the greatest disturbance problems in southern California appeared to be King Harbor and Dana Point. The primary roost

SOUTHERN CALIFORNIA

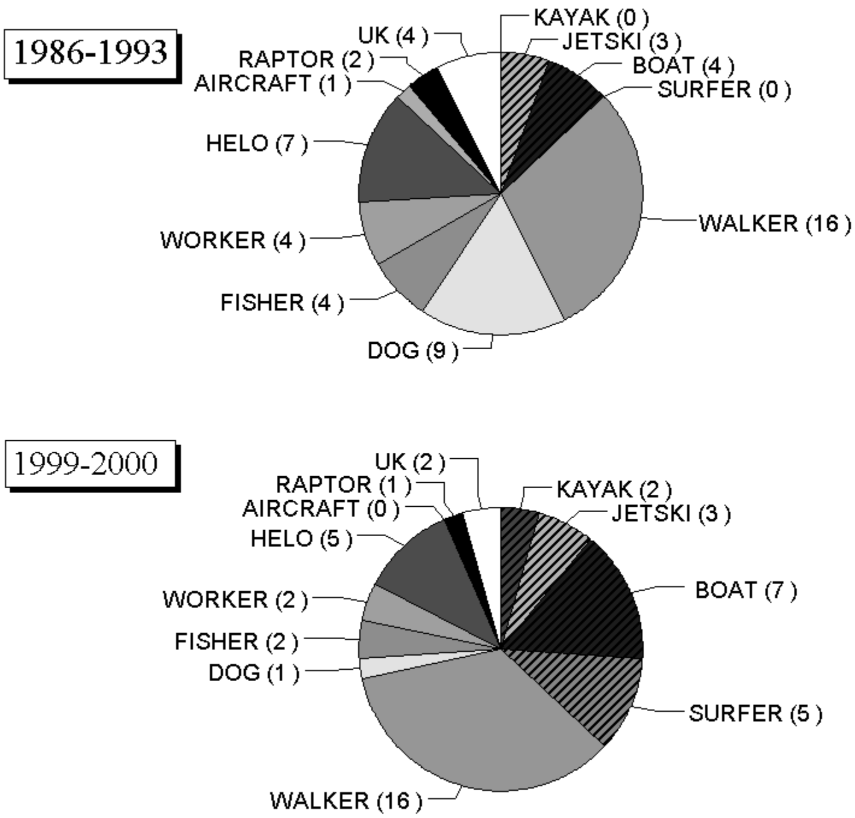

Figure 2. Sources of disturbance to Brown Pelicans at roosts in Southern California as observed in 1986-1993 (top chart) and 1999-2000 (bottom chart). See text for definition of source categories. The number in parenthesis represents the total number of observed disturbance events due to a given source in each time period. The shaded area indicates categories collectively referred to as “water sports” in text.

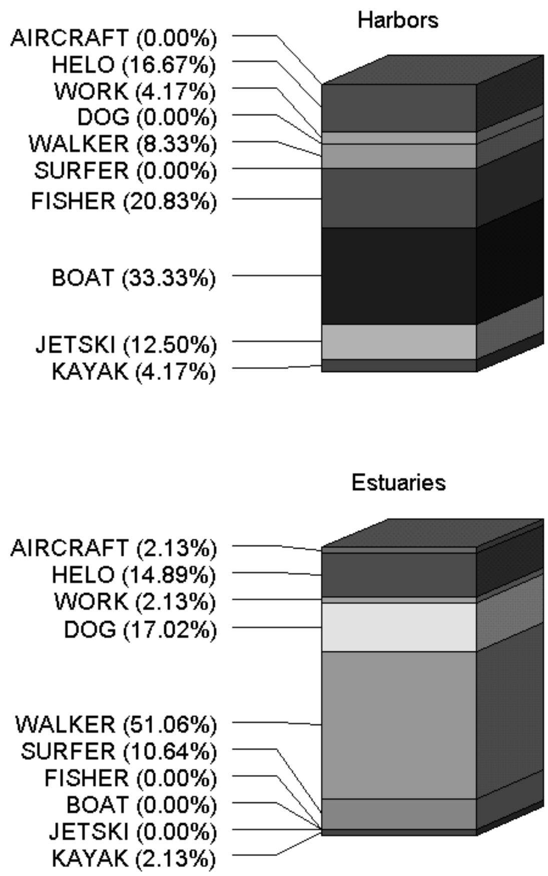

Figure 3. Sources of human disturbance to Brown Pelicans at roosts by habitat type in Southern California. "Harbors" refers to all types of roost substrates used within harbors, and "estuaries" refers to all estuarine habitats, including lagoons and river mouths. Disturbance categories are described in text. The number in parenthesis represents the percentage of the total observed disturbances caused by a given source within each habitat type.

Table 2. Brown Pelican response to different disturbance sources in Southern California.

Disturbance source category	**Number of events in sample**	**Number of pelicans flushed**	**Mean Number Flushed per event**	**Number that departed roost entirely**	**Number that relocated within roost**	**Number that returned to same site**
Fisherman	4	95	24	49	51	0
Surfer	5	125	25	11	66	45
Jetski	6	168	28	0	58	110
Kayak	2	202	101	3	199	0
Boat	11	206	19	18	81	87
Worker	5	330	66	44	153	133
Dog	6	360	60	58	128	210
Helicopter	8	443	55	46	191	206
Walker	26	2076	80	218	1086	79
Total		**4005**	**51**	**447**	**2013**	**870**

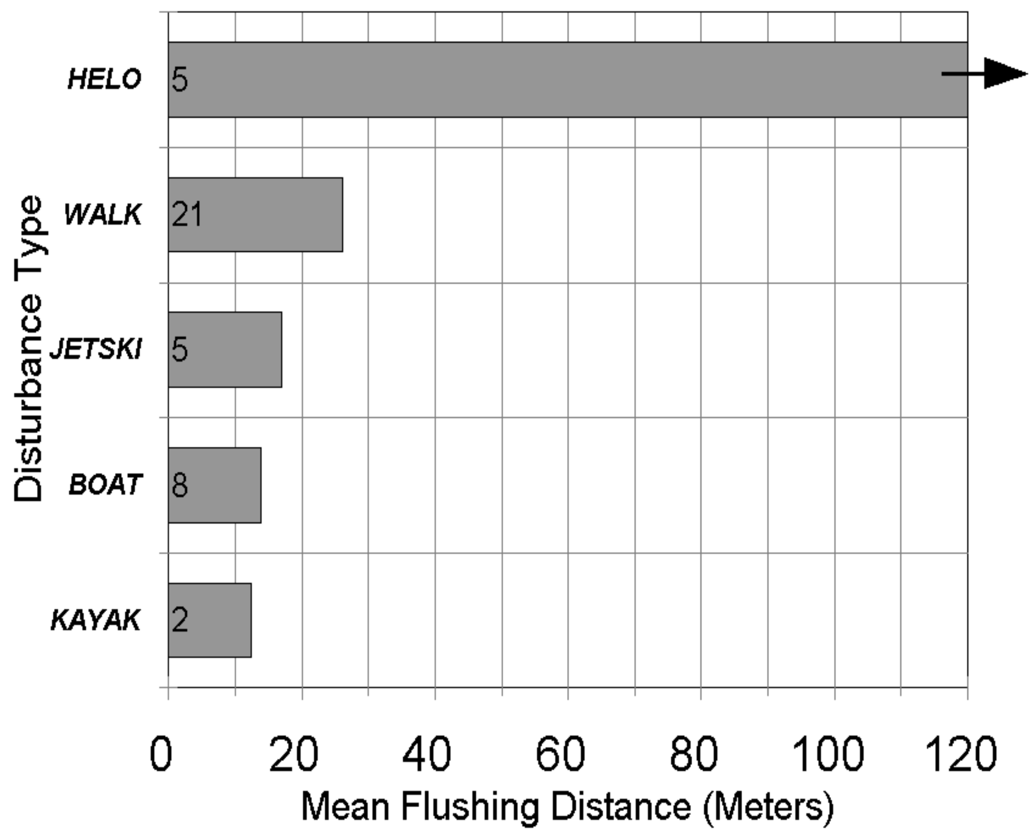

Figure 4. Mean distances (in meters) at which Brown Pelicans flushed from roosts in Southern California from various types of human disturbance. Disturbance types are defined in text. Number at base of bars represents the number of disturbance events in which flushing distance was estimated for each source. The mean flushing distance for helicopters was 312 meters.

sites at each of these harbors were attached jetties, rather than detached breakwaters. The examples below describe some of the dynamics of disturbance at these sites, including how it related to habitat characteristics at each roost.

Malibu Lagoon ***(LA 16.0)*** had the highest disturbance index of all sites observed in 1999-2000, due to high use by young pelicans and heavy disturbance from a variety of sources during the two dates it was visited (Table 1). As many as 339 pelicans were present (90% immature birds at peak census) and 18 disturbance events were recorded over 6.2 hours. Five disturbance events were caused by surfers walking or wading through the area and six were caused by other beach and park visitors, including one child who intentionally chased pelicans off of the beach berm. A kayaker that paddled through the middle of the small lagoon caused the most severe displacement of roosting and bathing birds. Three helicopter disturbances, and one patrol car disturbance also occurred, as well as two disturbances from unknown causes.

Roosting substrate availability and use varied according to lagoon configuration, tidal height and disturbance. When the lagoon was open, gravel bars surrounded by shallow water were available within the lagoon. When the lagoon was closed, these bars were submerged and the only island habitat available was a relatively small branched piece of driftwood. In this case the primary roost site was the sand berm separating the lagoon from the ocean, except during low tides, when a cobble bar was available in the intertidal region. Disturbance occurred in all of these locations and birds were forced to relocate within the roost numerous times, spending much of the time after disturbances floating in the water. Despite this, pelicans were tenacious to the site overall. Only 62 birds were known to depart the roost, of the total 1,146 bird flushes due to disturbance, during the two observation dates in 2000. The disturbance rate at Malibu Lagoon was higher than recorded in 1986-93 (Table 1).

The **Santa Clara River** mouth ***(VN 7.0)*** has historically been a relatively heavily disturbed roost site and continued to reflect this characteristic in 2000 (Table 1). The implications of variation in availability of roost habitat due to changes in water levels at this site were illustrated on the two dates the roost was observed in 2000. On the first date, the lagoon was open to the sea and sandbar roost habitat was available inside the lagoon. No human disturbances were recorded although public use of the surrounding area was high. The number of birds increased from 10 to 51 over the two-hour observation period. On the second date, the lagoon was closed and the birds roosted on the outer sand berm between the ocean and the estuary. Disturbance was chronic; birds were flushed seven times in three hours. The primary response to people walking on the beach was to relocate into the lagoon and remain swimming for many minutes before gradually coming back out onto the berm. In contrast to this, when an unleashed dog was allowed to chase the pelicans off the beach, most of them (30 of 38) departed the roost entirely. The chronic disturbance and lack of alternate dry roost habitat within the lagoon did not allow numbers of birds to increase; 13 pelicans were present at the start of observations, 74 were flushed, and 19 were present at the end of three hours. Like Malibu Lagoon, this site was used predominantly by young birds on the day of heavy disturbance (82% immature pelicans at peak census).

Historic data were limited for the **Tijuana River mouth** ***(SD 1.0)*** and it was not visited in 1999-2000. Pelicans attempting to use the site during two visits in 1986 were flushed repeatedly from inside and around the lagoon. Disturbance sources included recreational park users, illegal immigrants wading across the wetland, helicopters, horses and raptors. Like other heavily disturbed estuarine sites, this location was used predominantly by immature pelicans. Seven disturbances occurred in four hours on one date when up to 300 pelicans (90% immature) were present.

Pelicans roosted in three general areas of **King Harbor** ***(LA 11.0)***, on the long outer jetty, a short inner jetty, and on a bait barge. The outermost tip of the long jetty was used regularly by fishermen, so the birds tended to roost near the middle bend of the jetty. Each time a fisherman walked the length of the jetty pelicans were forced to move. The tip of a short inner jetty was also used as a secondary roost, presumably due to chronic disturbance on the long jetty. The inner jetty was disturbed by fisherman on foot as well as watercraft passing particularly close to the roost. A jet ski and a tour boat were the only vessels observed to disturb pelicans. Pelicans roosting on the bait barge flushed when the site was accessed for bait. On average, 76% of the pelicans that used this site in 2000 were immature (Strong and Jaques 2001).

At **Dana Point** ***(OR 3.0)***, the physical configuration of the harbor, roost site selection, and the types of disturbances that affected roosting pelicans were very similar to King Harbor. However, the main jetty at Dana Point is much longer than at King Harbor and people appear to be less likely to walk the entire length of it to reach the tip to fish. The boat disturbances noted at this site were from a jet ski and a canoe. Pelicans were clearly habituated to relatively close approach from other motorized boats. Adults comprised 55% of all brown pelicans surveyed at this site in 2000 (Strong and Jaques 2001), perhaps reflecting it's lower tendency for disturbance than at King Harbor.

Central California

We evaluated 95 disturbance events in the Moss Landing area (61 historic and 34 from 1999-2000) and 40 at Pismo-Shell Beach (23 historic and 17 from 1999-2000). Total observation hours for each site and each period are provided in Tables 3 and 4. Changes in frequency and type of disturbance characteristic to both of these central California areas were documented. Disturbance from shore-based fishermen, helicopters and dogs apparently decreased while disturbance from kayaks and tour boats increased (Figs. 5 and 6). The number of pelicans flushed in the Moss Landing area was 9,397 in the historic data set and 1,679 in 1999-2000. Numbers of pelicans observed flushed at Shell Beach was 1,307 historic and 753 in 1999-2000.

Pismo-Shell Beach Area

The Pismo-Shell Beach area consists of fairly contiguous band of offshore rocks, cliffs and pocket beaches. The rocks are the predominant roost type, although cliffs are also used by pelicans. There is one large rock (Pismo Rock) about 1/4 km offshore, but the remainder of the rocks are relatively small, very near to shore, and adjacent to the town of Shell Beach. Mainland

Table 3. Disturbance at Brown Pelican roosts in the Pismo and Shell Beach Rocks area, 1986-1991 and 1999-2000. Disturbance is presented as frequency of flushing events per hour of observation (N). " D" is the disturbance index described in Methods and pertains only to data collected in 1999-2000.

Roost No.	Roost Site	1986-1991			1999-2000			
		Human	Natural	N	Human	Natural	N	D
SL-1.0	Pismo Rock	0.09	0.05	(21.8)	0.0	0.0	(3.1)	0
SL-1.1	Pismo Rock area	0.64	0.21	(14.2)	ND	ND	0	-
SL-2.0	Shell Beach Rocks	0.20	0.12	(25.5)	1.16	0.16	(12.9)	31.0
	Pismo -Shell Beach Total	**0.26**	**0.12**	**(61.5)**	**0.94**	**0.13**	**(16.0)**	

Table 4. Disturbance at Brown Pelican roosts in the Moss Landing area, 1986-1991 and 1999-2000. Human and natural disturbance indicates the frequency of flushing events per hour of observation (N) for each category. "D" is the disturbance index described in Methods and pertains only to data collected in 1999-2000. Research and hunting-induced disturbance at Moss Landing were excluded from this analysis.

Roost No.	Roost Site	1986-1991			1999-2000			
		Human	Natural	N	Human	Natural	N	D
MO-17.0	Moss Landing Wildlife Area	0.03	0.06	(345)	0.55	0.17	(29.1)	33.7
MO-18	Elkhorn Slough	0	0	(0.5)	2.63	0.26	(3.8)	45.6
MO-16.0	Moss Landing Harbor	0.60	0.12	(18.4)	0.91	0	(1.1)	-
MO-15.0	Salinas River Mouth	0.77	0.39	(15.5)	4.0	0	(0.3)	-
	Moss Landing Area Total	**0.09**	**0.12**	**(379)**	**0.82**	**0.18**	**(34.3)**	

SHELL BEACH

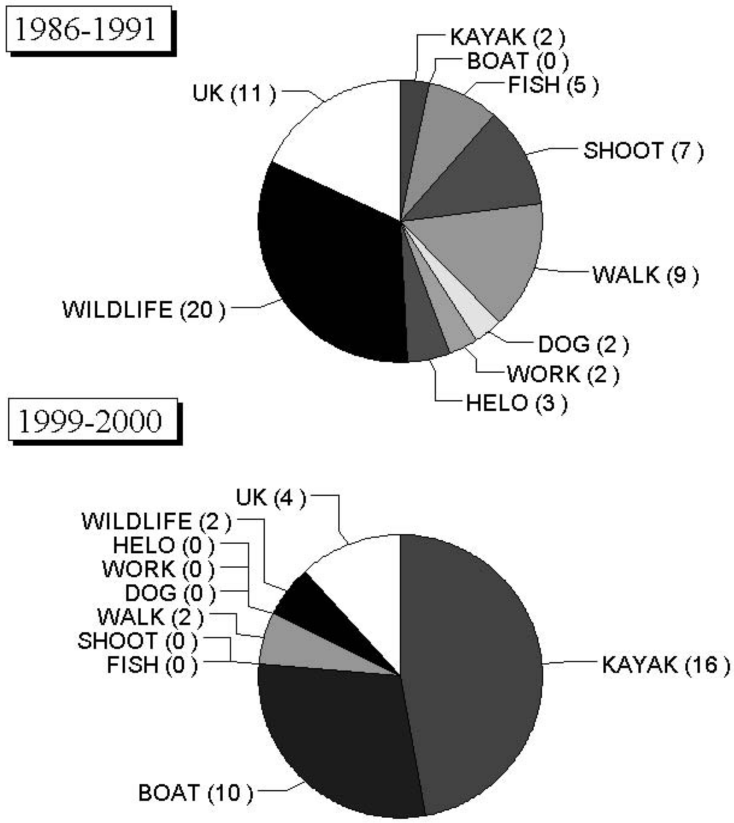

Figure 5. Sources of disturbance to Brown Pelicans in the Pismo-Shell Beach area as observed in 1986-91 (top chart) and 1999-2000 (bottom chart). See text for definition of source categories. The number in parenthesis represents the total number of observed disturbance events due to a given source in each time period.

MOSS LANDING

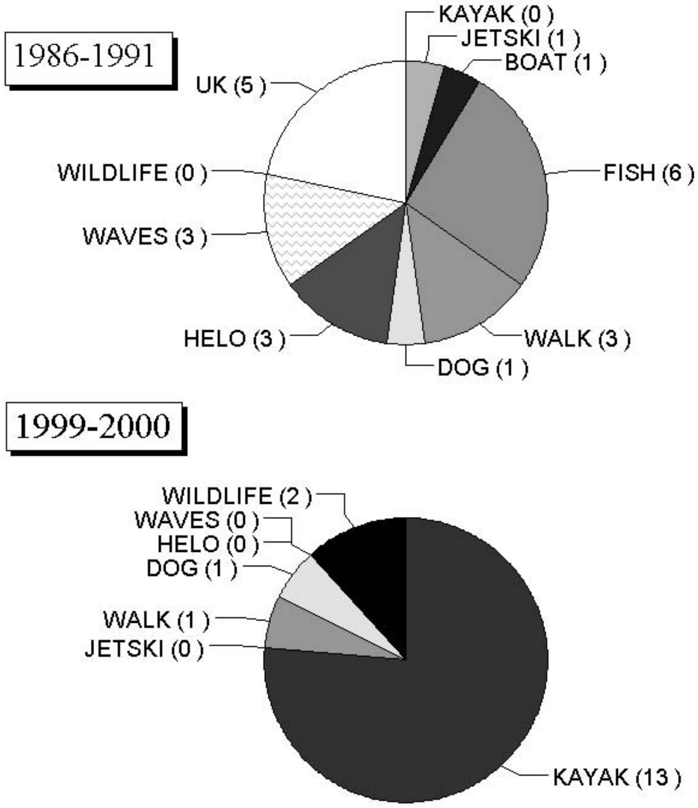

Figure 6. Sources of disturbance to Brown Pelicans in the Moss Landing area as observed in 1986-91 (top chart) and 1999-2000 (bottom chart). See text for definition of source categories. The number in parenthesis represents the total number of observed disturbance events due to a given source in each time period.

cliffs and beaches in the Pismo Rock area were grouped together as the 'Pismo Rock Area' roost. The frequency of human disturbance at the Pismo-Shell Beach Rocks increased and the type of disturbance changed over time. The documented disturbance rate at Shell Beach Rocks in 1999-2000 was 6 times greater than in 1986-91 (Table 3). This was due to the relatively new popularity of kayaking around the nearshore rocks. No kayak disturbances were documented in the historic period during 62 hours of observation, whereas 13 kayak disturbances were observed in 1999-2000 during 16 hours of observation (Fig.5). Kayaks accounted for 77% of all disturbances in the Pismo-Shell Beach area, and 87% of all human disturbances. People had been observed using rubber boats to land on the nearshore rocks during 1986-87. Although there was evidence that people still land or climb onto the rocks, no disturbances of this type were witnessed in 1999-2000. The mean number of pelicans flushed per hour at Pismo-Shell Beach rocks from all sources was 21.3 birds/hour in the historic period and 47.1 birds/ hour in 1999-2000.

No disturbances were documented at nearby Pismo Rock or in the 'Pismo Rock Area' in 1999-2000. Historic disturbance at Pismo Rock included one event where persons in wet suits swam out to the island and climbed up on it, flushing hundreds of birds. The potential for disturbance in the 'Pismo Rock Area' was lower due to loss of a previously used beach roost site. There was formerly a pocket beach below the cliffs that was inaccessible to the general public until a cliff top hotel built steps down to it in 1987. Pelicans appeared to have abandoned that site completely by 1999, leaving only cliff face roost habitat at the 'Pismo Rock Area' site.

Moss Landing Area

The roost sites in the Moss Landing area included three estuarine sites, the Moss Landing Wildlife Area (which is part of Elkhorn Slough), other areas in Elkhorn Slough, the Salinas River mouth, and the Moss Landing Harbor. A mix of natural and artificial roost substrates were used within Moss Landing Harbor. Roost site availability and selection at the Salinas River mouth varied depending on the water levels in the estuary. The primary roost types at the Moss Landing Wildlife Area (WA) were eroded exterior earthen levees along the north bank of Elkhorn Slough and interior managed wetland ponds. An eroding levee on the south bank of Elkhorn Slough, directly across from Moss Landing WA, was the second most frequently used roost site in the area and could be considered as part of the same roost as at the WA. Habitat conditions at Moss Landing and Elkhorn Slough have changed greatly since the late 1980's when most of the historical data were collected. Prior to reconstruction of the area by the CDFG in 1988, the primary pelican roost habitats were the interior levees of a former salt works operation and relic ponds with permanent shallow water (Jaques and Anderson 1988). Use of the Moss Landing Wildlife Area by pelicans was historically higher and use of other areas in Elkhorn Slough was negligible, compared to recent years.

Frequency of human disturbance to Brown Pelicans in Elkhorn Slough and the Moss Landing Wildlife Area was extremely high in 1999-2000 compared to the 1986-1991 level (Table 3). The two areas together were disturbed by human impacts nearly every hour (0.9 events/hr) in 1999-2000 compared to once every 33 hours historically (not including the waterfowl hunting season in either case). The Salinas River mouth and Moss Landing Harbor were found to be far more heavily disturbed than the Elkhorn Slough sites historically, but not enough data were collected at these surrounding roosts in 1999-2000 to evaluate more recent status.

The increase in disturbance at Moss Landing and Elkhorn Slough reflected the changes in roost site availability and water level management within the Wildlife Area, along with increased disturbance due to an explosion of water-based "ecotourism" and kayak use in Elkhorn Slough. Kayaks and boats accounted for 77% of all disturbances in the Moss Landing area in 1999-2000 (Fig. 6). Only 2 kayak or boat-based disturbances were observed in the Moss Landing area (both in the harbor) during 380 hours of observation in the historic period, versus 26 events during 34 hours in recent period. Pelicans were relatively immune to boat based disturbances when they had adequate roost habitat in the interior regions of the Wildlife Area.

Natural disturbance by raptors and other birds was more common than human disturbance at the Moss Landing WA area in 1986-1991 (Table 3). Most of the historic disturbances by fishermen (including clammers) in the Moss Landing area took place in the harbor.

The mean number of pelicans flushed per hour in the Moss Landing area (due to both natural and anthropogenic sources) was 24.8 birds/hour in the historic period versus 49.4 birds/hour in the recent period.

DISCUSSION

Human disturbance in estuaries appears to have the most severe negative effects on roosting Brown Pelicans in southern California, relative to disturbance in other available habitats. Flushing distances were greater, disturbance was more frequent, and the total numbers of pelicans affected by disturbances were higher in these natural habitats compared to the artificial roost environments observed. Jaques et al (1996) also found that human disturbance in southern California tended to be greater in estuarine habitats than in harbors, based on more limited data. The severity of disturbance events in harbors tended to be fairly low, considering the intense level of human activity in the surrounding area. Pelicans displayed habituation to the most common type of boat traffic in harbors and chose roost sites that were relatively inaccessible to persons on foot. Artificial structures on the outer coast, other than those associated with harbors, have historically been some of the least disturbed sites, but there were few of these roosts remaining by 1999. We did not collect enough data in what remains of this habitat type (e.g. Rincon Island and Sandpiper Pier), to evaluate disturbance due to access issues.

Greater sensitivity of pelicans to human approach in estuarine settings compared to harbors may relate to the higher likelihood of natural mammalian predation and less effective buffers at coastal wetlands. Variation in responses to disturbance by the same species of birds in different habitats have been documented for other waterbirds (Joselyn et al. 1989, Bratton 1990). The flushing distances observed in southern California estuaries, however, were lower overall than reported for Moss Landing (Jaques and Anderson 1988) and observed in other regions of the Brown Pelican range (D. Jaques, unpublished). Data suggest that pelicans are more tolerant of or "habituated" to human presence in some southern California coastal areas, compared to roost sites where human presence is relatively rare.

Human disturbance in southern California does appear to be an important factor involved in deterring pelicans from using natural habitats (i.e. estuaries, river mouths, creek mouths, lagoons, rocky shorelines and beaches) and favoring the use of artificial habitats. Data from the analysis of distribution and abundance in southern California showed that artificial roost sites supported 66% of roosting pelicans along the mainland on average, and that these sites were occupied more consistently than natural sites (Strong 2002). In the northern portions of the California Brown Pelican's nonbreeding range, natural habitats along the mainland, including creek mouths, river mouths, other estuarine sites, and some beaches, are used heavily as roost sites (Briggs et al. 1983, Jaques 1994) and artificial substrates comprise a relatively small portion of the habitat selected.

Jaques and Anderson (1987) found an inverse relationship between the presence of adult pelicans and disturbance level within various habitats in central California. These and other data suggested that Brown Pelicans learn, over time, to avoid chronically disturbed locations. Learned avoidance of heavily hunted areas has been documented in geese (Ebbinge 1991).

Observations of the worst cases of chronic disturbance that we documented in southern California involved a large proportion of immature birds. A recurring pattern of young birds being drawn to naturally attractive shoreline features such as rock promontories (e.g. Point Loma) and freshwater outlets, and then encountering high rates of human disturbance, seems to exist in southern California. Immature birds are the most likely to be energetically stressed due to lower foraging success than adults (Orians 1969), and have a high mortality rate in the first year (Anderson and Gress 1983), mostly due to starvation. It follows that birds that continually encounter high disturbance levels will have a lower chance of survival, compared to birds that learn to roost in relatively undisturbed habitats. This study indicates that disturbance in natural areas may be incurring relatively high costs to immature pelicans and precluding regular use of otherwise desirable habitats by adults.

Estuaries and other coastal wetlands were probably the key mainland roost sites prior to development of the southern California shoreline. These habitats serve a variety of functions for Brown Pelicans, including bathing, pouch-washing, and in some cases, foraging. Mugu Lagoon may be the only estuarine site in southern California that can be considered a regularly used, high quality roost for brown pelicans (Jaques et al 1996, Capitolo et al.2002, this report). Ownership and management by the U.S. Navy have restricted access and limited disturbance at the site, compared to other areas in southern California. In contrast, Malibu Lagoon and the Santa Clara River mouth are managed as State Parks and are subject to intense human recreation. Some of the lagoons in San Diego County are managed for wildlife and are well buffered from human disturbances, but lack roost habitat suitable for Brown Pelicans. Some roost habitat was historically available near the mouth of Batiquitos Lagoon, but this was eliminated by habitat modification for other endangered species. Man-made structures provided roost habitat in Agua Hedionda Lagoon, but this roost site was in the process of being purposely eliminated in 2000 (Strong 2002).

Although they are not managed as wildlife habitat, the many artificial structures and harbors along the southern California coast are a critical component of nonbreeding habitat for Brown Pelicans. The presence of large aggregations of pelicans in harbors, however, can have negative impacts as well. Pelicans using harbors to roost are more likely to encounter oil and other contaminants, are more likely to become entangled in monofilament, and may become regular scavengers or 'pan-handlers.' Pelicans frequenting harbors are also more likely to be involved in negative interactions with humans such as interfering with sport and commercial fishing, causing private property damage, becoming a public nuisance, or being maimed or killed by malicious persons.

Efforts to reduce human disturbance in southern California will target different user groups, primarily different types of recreationists, according to general roost site habitat. The key user groups in harbors that would need to be reached or restricted are boaters and fishermen, whereas the primary users in estuaries would be persons walking on the beach. The increase in the proportion of disturbance due small watercraft and surfers in the recent versus the historical period may reflect an increase in the popularity of these watersports.

Data in this report regarding the characteristic types and effects of disturbances for the Southern California region will aid in development of specific management or restoration recommendations. Recent data for individual sites in southern California were generally limited to a few hours of observation, however, and should not be considered comprehensive. The 1999-2000 observations also took place only in two periods, summer and early fall. There may be other factors that are important in winter and spring. Larger swell size, greater freshwater runoff, differences in fishing seasons and human recreation tendencies are examples of seasonal factors that may change patterns of roost use and human disturbance.

Other types of disturbance not identified in this study may be significant or may become relevant over time. Intense sodium lights from squid boats have been observed to disrupt activity patterns of Brown Pelicans at Anacapa Island (F. Gress, U.C. Davis, pers. Comm). Birdwatching and kite-flying are examples of recreational activities that could cause chronic disturbance at some roosts. Research has been identified as a source of disturbance to roosting pelicans (Jaques and Anderson 1988, Wright 2002). There is a need for review of potential conflicts wherever research field sites and major pelican roosts physically overlap. Changes in habitat, recreational trends, industrial developments, scientific interests, and other factors affecting human and pelican presence in the landscape will change the nature of disturbances at some sites. Periodic monitoring and adaptive management strategies may be required for long-term protection of roost sites that are vulnerable to disturbance.

RECOMMENDATIONS

Southern California

The results of this study, and the above discussion of harbors versus estuaries, suggest that restoration actions geared towards reducing human disturbance at existing roosts in southern California should prioritize natural areas. It may be more difficult to achieve the goal in natural habitats, however, the long-term ecological benefits to pelicans and other waterbirds species are likely to be greater. Some harbor structures or man-made structures on the outer coast remain very good candidates for enhancement, as discussed below. Tables 5 and 6 summarize our recommendations.

Harbors

Recommendations to improve habitat in harbors have included installation of fences on jetties to prevent disturbance from people walking out to the tips (ATTC 2001). Fishermen were the only people that we observed on the tips of long jetties with important roosts. Both pelicans and fishermen appear to prefer the tips of jetties. Precluding fishermen from tips of jetties would probably be very effective in reducing disturbance, including the indirect disturbances that pelicans encounter when they move to less preferred habitats within the same harbor after a disturbance. This might lead to greater numbers of pelicans using those jetties where fencing was installed. However, the value of allowing more pelicans to rest undisturbed on jetties needs to be weighed against the negative implications of greater pelican use of harbors. This action would also likely be perceived as restriction of the rights of shore fishermen, a group that directly caused only 6% of all disturbances documented in southern California. Vandalism, an increase in negative perceptions of pelicans, and increased potential of intentional killing or maiming of pelicans by fishermen may result from this action at popular fishing locations. In contrast, jetties that are not associated with intensive public use and that can be restricted for other reasons may be good candidates for fencing. A jetty in Anaheim bay was fenced off historically due to restrictions associated with government property. Other jetties in California are closed to public access due to safety concerns.

Placement of buoys around breakwaters to create a buffer zone between boats and pelicans has also been discussed. This may effectively prevent some disturbances, such as from tourboats, but the buffer is likely to be violated by the users of watercraft such as jetskis, kayaks and other small boats. These smaller vessels caused the most disturbance. Enforcement of a buffer zone would be necessary if it were to be effective. The overall positive benefits to pelicans are likely to be fairly negligible if there is no enforcement. Problems associated with the buoys causing hazards to navigation in some fairly narrow channels also need to be considered. Based on observed flushing distances in this study, a buffer of 30 meters would preclude all boat-based disturbance, and a 20 meter buffer would eliminate 75% of disturbances. The distance at which most boats pass *without* causing disturbance, and the distance required for boats to safely pass through a given area should be evaluated and added to the assessment before specific plans are proposed for this type of potential restriction.

Table 5. Summary recommendations to reduce human disturbance of roosting pelicans in southern California estuaries.

Target Human User Group	***Project Description***	***Pros***	***Cons***	***Locations***
Walkers, Fishermen, Surfers, Kayakers, Dogs	*Develop education materials targeted to instill an awareness and ethic about protecting pelicans and other seabirds from disturbance*	*Decrease disturbance of roosting pelicans*	*Interpretive displays may be subject to vandalism*	*Malibu Lagoon, Santa Clara River mouth, Tijuana River mouth*
		Increase use of coastal wetland habitats by pelicans and associated waterbirds	*Success depends on voluntary behavioral modification*	
	Restrict human access within 25 m to 30 m by modifying trail patterns (may be temporary or permanent), create temporary closures to foot traffic or boats	*Same as above*	*Need for onsite management personnel to implement changes in trails and/or maintain experimental closures*	*Malibu Lagoon, Santa Clara River mouth, Tijuana River mouth*
		Creates or increases regulatory buffer distance between pelicans and people	*May require regulatory enforcement*	
General Disturbance including Walkers, Fishermen, Dogs	*Create island roost habitat within wetlands using natural or artificial substrates. Alternatives include earthen islands, artificial floating structures or pile-supported structures.*	*Increase habitat availability and decrease disturbance by providing dry substrate surrounded by water buffer*	*Permitting may be difficult*	*Mugu Lagoon, Bolsa Chica, Agua Hedionda, San Elijo, Batiquitos, south San Diego Bay*
		Does not restrict recreational opportunities or rely on voluntary changes in human behavior	*Costs for earthen islands may be relatively high, artificial structures may need to be maintained.*	
	Enhancement of roost sites by increasing elevation of existing islets	*Same as above, increased habitat during high water, may not be considered wetland fill*	*Permitting may be difficult*	*Same as above*
	Provide artificial roosting substrate such as driftwood	*Same as above, as well as relatively easy to implement and natural in appearance*	*Limited available space for pelicans on driftwood, may require annual replacement*	*Same as above.*

Table 6. Summary recommendations to reduce human disturbance of roosting pelicans in southern California harbors.

<table>
<tr><th>Target Human User Group</th><th>Project Description</th><th>Pros</th><th>Cons</th><th>Locations</th></tr>
<tr><td rowspan="2">Fishermen</td><td rowspan="2">Installation of fences on tips of long jetties to block access to fishermen on foot</td><td rowspan="2">Decrease disturbance and displacement of pelicans from jetty roosts, may elevate status of some diurnal roosts to night roosts, may reduce pelican use of boats, piers, buildings, and other private property in harbors</td><td>May restrict rights of fishermen</td><td rowspan="2">The longest jetties at Dana Point, King Harbor, Oceanside, Anaheim Bay and potentially others</td></tr>
<tr><td>May increase pelican use of harbors overall, resulting in increased negative human-pelican interactions</td></tr>
<tr><td rowspan="4">Kayaks, Jet skis, Other Boats</td><td>Placement of signs informing boaters that landing on breakwaters and similar structures is not permissible</td><td>Decrease disturbance, flushing and displacement of pelicans by boaters landing on or near roosting sites</td><td>None identified</td><td>Breakwaters at Marina del Rey (priority site), Ventura Harbor, Channel Islands Harbor and potentially others</td></tr>
<tr><td rowspan="3">Placement of buoys around breakwaters to create a 20 m to 30 m buffer zone between boats and pelicans</td><td rowspan="3">Decrease disturbance and flushing of roosting pelicans from near approaches by boats</td><td>May restrict activities of large, well-informed tour boats, but not small boats such as kayaks and jet skis (small boat operators were observed to cause the most disturbance)</td><td rowspan="3">Breakwaters at Marina Del Rey, Ventura Harbor, Channel Islands Harbor and potentially others</td></tr>
<tr><td>Enforcement important yet difficult</td></tr>
<tr><td>Buoys may cause navigation hazard</td></tr>
</table>

The most severe disturbance scenario for harbors is having boats land on important breakwater roost sites. We observed people on breakwaters at Channel Islands Harbor and Ventura Harbor, but did not witness the landings and disturbance events directly. It is against Army Corps policy for persons to access the breakwaters, but there is no obvious source of public information on this. We recommend that signs be placed on the breakwaters and at boat access points, informing people that the structures are not available for public use. The most important breakwater to protect is at Marina del Rey.

Estuaries

Based on existing data, we recommend action to reduce disturbance at Malibu Lagoon and the Santa Clara River mouth. Creation or enhancement of roost habitat within less disturbed wetlands, such as South San Diego Bay or Batiquitos Lagoon, may be more successful and has been identified as a high priority (C. Gorbics, USFWS, pers. comm.). Provision of a high quality roost site in South San Diego Bay, may indirectly help alleviate problems at Tijuana Slough, by providing a nearby alternate roost.

Efforts to reduce disturbance at Malibu Lagoon and the Santa Clara River mouth should include working with the California Department of Parks and Recreation (CDPR) to develop interpretive materials to help instill an awareness and ethic about disturbing pelicans and other waterbirds. Review of the human traffic patterns and trails at Malibu Lagoon may reveal some specific options for modifying human access patterns to reduce disturbance to the wetland area. When the lagoons are closed, however, pelicans are likely to be on the outer beach where it may not be possible for a person to walk the beach at high tide without impacting pelicans at the edge of the lagoon. We recommend that experiments with temporary closures around typical beach berm or sand spit roost sites take place. These could be set up using cones, ropes or signs. We observed infrequent violation of Snowy Plover and Least Tern exclosures at State Parks. A minimum buffer zone of 25-30 meters between human traffic and pelicans would be required. A buffer distance of 30 m or more to protect wetland birds was recommended by Josselyn et al. (1989).

Changing the distribution of the pelicans by modifying habitat would be more effective in reducing disturbance than trying to alter the behavior of people. Enhancement of natural islets within the estuaries to raise the elevation of roost sites above the high water level or provision of additional natural substrate such as driftwood would be an effective means to provide a water buffer between park users and pelicans. Islets made of natural substrate may not be permanent due to erosion during heavy runoff periods, but could serve pelicans for a number of years. Sand spurs facing into the estuary off the estuary might be more easily created and would also reduce disturbance potential. Although habitat manipulation is accepted at wetlands managed for wildlife, the support for these projects may not be likely in dynamic coastal wetlands managed by the CDPR. Placement of woody debris in coastal estuaries has taken place as part of salmon enhancement efforts in northern California. While the woody debris option would provide substrate for fewer pelicans, it may be more likely to be permitted.

Creation or enhancement of island roost habitat would be effective at many coastal wetlands that have restricted or limited public use, including Mugu Lagoon, Bolsa Chica, Agua Hedionda, San Elijo, Batiquitos, and South San Diego Bay. Artificial floating or piling-supported structures would probably be the most cost effective means to accomplish this. Formation of artificial or earthen islands surrounded by adequate permanent water buffers would result in reduced disturbance to pelicans without restricting recreational opportunities or relying on voluntary changes in human behavior.

Provision, enhancement, or retention of artificial structures outside of harbors on the outer coast remains a justifiable restoration objective. These sites may provide pelicans with the least disturbed environment and greatest benefits relative to detection of foraging opportunities.

Central California

A surprising result of this study was the finding that human disturbance at the locations we observed in central California in 2000 was more severe than that documented in most of southern California. The increase in disturbance at Elkhorn Slough and Shell Beach Rocks, which are two of the most important roost sites in the state of California, would seem to demand immediate attention by the natural resource agencies involved in managing those sites. Development of specific management plans, information and education efforts, and restrictions on public use for those areas is highly recommended. Specific recommendations can be provided if the American Trader Trustee council is considering implementing projects outside of southern California. The basic concepts presented in the restoration plan for these sites (ATTC 2001) were further validated by this study.

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